National Transportation Safety Board

Office of Marine Safety Washington, D.C. 20594

Addendum 1 to the Survival Factors Group Chairman Factual Report

El Faro DCA16MM001

Survival Equipment Mentioned in VDR Transcripts

Investigators reviewed the NTSB electronic data group chairman's transcript of the audio recorded by *El Faro*'s voyage data recorder (VDR) on September 30, 2015, and October 1, 2015, to discover any mention of survival equipment in the hours before the accident. Table A1-1 reproduces the statements recorded on the VDR concerning lifeboats, liferafts, EPIRB, lifejackets, immersions suits, and fire and boat drills.

Table A1-1. Survival equipment mentioned on VDR transcript.

Date / Time	Person	Statement
30-Sep-2015		
06:09:44.5	Chief Mate (CM)	good. then that's our first order of business. right? (our) second order of business.
06:09:51.8	Captain	chat. makin' sure all his boys got all their rounds– (stocks)– doors– (gotta get) the lifeboats (here). It's just * *.
06:10:01.8	CM	(I'll) talk to my guys as well.

Date / Time	Person	Statement
19:50:47.8	CM	um what's the problem here?
19:50:51.0	Third Mate (3M)	I (can/did) put a couple uh– umm– car straps on those two life rafts– just in case.
19:50:56.4	Chief Mate (CM)	excellent.
19:50:57.9	3M	**** and the hospital and the slop chest and things the first [references the AE] asked me to secure.
19:51:05.4	CM	* * *.
19:51:08.6	3M	I know.
19:51:12.0	3M	* *– I saw what you did with the shackle * that's fine for now. I didn't use that long shackle down there because (neither one of those) life raft– that's the one with the cables attached to it like they * * all over. * * *.
19:51:28.9	CM	(couldn't get anything a little longer) * * *.
19:51:31.9	3M	I tried to turn it so * * *. I'll we'll get it right. I didn't wanna bother the boatswain today. I– I didn't find anything (out there) * * *. we'll– we'll get it.
23:27:11.2	3M	I trust what he's saying– it's just being twenty miles away from hundred knot winds– this doesn't even sound right.
23:27:18.0	Able Seaman-3 (AB-3)	no.
23:27:20.1	AB-3	(no matter) which way it's hittin' ya.– still hundred knot winds.
23:27:35.7	AB-3	(I got a feelin') poopy suit [immersion suit] and my life jacket.— laid out.
23:27:54.9	AB-3	Flashlight.
23:28:11.3	AB-3	(it's good to) know that @Steward Assistant and @Chief Cook will get the EPIRBs. [sound of laughter] man.
23:28:17.6	3M	right. " * * up there." [3M was imitating someone.]
01-Oct-2015		
00:45:01.9	2M	* * this is zero six hundred now it moves up to four. and we're up here headed right toward it. now we're gonna hit it at four oh clock in the morning.
00:45:24.2	AB-2	what he's thinking?
00:45:28.2	2M	@3M told him the latest (weather report was here/heading of the storm/news about the storm).
00:45:31.9 00:48:07.5	--	[Area of non-pertinent conversation or no conversation.]
00:48:07.5	AB-2	@AB-3 said he had his survival suit ready to go.
00:48:12.0	2M	[sound of chuckle]

Date / Time	Person	Statement
00:48:39.0	AB-2	hope it don't get to that point.
01:40:04.5	Second Mate (2M)	[sound of quick laugh] usually people don't take the whole umm– uh– survival suit– safety meeting thing very seriously. then it's "yeah– whatever. it fits" but nobody actually sees to see if their survival suit fits. I think today would be a good day [sound of laugh] for– for– for the fire and boat drill– just be like– "so we just wanna make sure everyone's survival suit fits" and then with the storm people are gunna (go/be like) "holy #. I really need to see if my survival suit fits– for reaaal." [laughter throughout]
01:40:34.5	2M	nobody ever takes these– the drills– seriously.
01:40:36.9	Able Seaman-2 (AB-2)	no. still have to do 'em.
01:46:12.3	2M	we don't have any lifejackets up here on the bridge[1]– do we? like the *El Morro*?
01:46:20.3	AB-2	* * *.
01:46:21.9	2M	cause I was thinkin' about that– safety stuff that was (on) the *El Morro*– we don't have over here.– it used to be in the * *. (they're not there/it was much better).

* Unintelligible word; # Expletive; @ Non-pertinent word, in most cases, an individual's name;
( ) Questionable insertion – the group either could not agree or was uncertain of a spoken word or phrase; [ ] Editorial insertion.

Survival Factual Report Table 1 (time corrected)

In the survival factors report, the times of the conversation reproduced in Table 1 are inconsistent with the times from the VDR (pages 470 to 474 of the VDR transcript). The table below corrects the times to match the times from the VDR transcription of the phone conversation between the AMAC Commercial Call Center operator[2] and the *El Faro* captain.

[1] *El Faro* June 2015 maintenance log, "SS El Morro Lifejacket Inspection," indicates 3 lifejackets on the bridge, 3 lifejackets in the engine room, and 2 lifejackets on the bow. "El Faro Pressure Tested Survival Suits" indicates 0 immersion suits on the bridge, 3 immersion suits in the engine room, and 1 immersion suit on the bow.

[2] Coast Guard Marine Board of Investigation exhibits 29 and 30: a single recorded phone conversation of 3 minutes, 5 seconds between the AMAC Commercial Call Center operator and the *El Faro* captain on the morning of October 1, 2015, about 0702; and MBI transcript of February 20, 2016, pp. 74-76.

1 **Table 1 (time corrected).** *El Faro* captain's conversation with call center operator, October 1.

Time	Person	Statement
07:01:00	Operator	*Okay sir.*
07:01:04	Captain	*This is a marine emergency. Yes this is a-ah marine emergency and I am trying' to uh notify a Q-I[a]*
07:01:35	Captain	*Are you connecting me through to a QI?*
07:01:38	Operator	*That's what I'm getting ready now. We're seeing who is on call and I'm going to get your right to them give me one second sir, I'm going to put you on a quick hold. So one moment please. Okay, sir. I just need your name please.*
07:02:27	Captain	*Yes, ma'am, my name is @CAPT. [Name, first - last.]*
07:02:31	Operator	*Your rank?*
07:02:32	Captain	*@CAPT. [Name, first - middle initial - last.]*
07:02:41	Captain	*Ship's master.*
07:02:50	Operator	*Okay thank you. Ship's name?*
07:02:52	Captain	*El Faro*
07:02:55	Operator	*Spell that E-L.*
07:02:58	Captain	*Oh man, the clock is ticking can I please speak to a QI?*
07:03:04	Captain	*El Faro, E-L F-A-R-O, El Faro.*
07:03:16	Operator	*Okay and in case I lose you what is your phone number please.*
07:03:25	Captain	*Phone number.*
07:03:27	Captain	*@. [phone number redacted.]*
07:03:39	Operator	*Got it.*
07:03:43	Captain	*That's my globe and let me give you my mini M.*
07:03:47	Captain	*You ready to copy?*
07:03:50.0	Operator	*Yes.*
07:03:50.9	Captain	*@. [phone number redacted.]*
07:04:01	Operator	*Got it sir. Again I'm going to get you reached right now, one moment please.*
07:05:12	Captain	*And Mate what else to do you see down there? What else do you see?*
CG MBI-2 2nd Audio 07:05:19	Operator	*I'm going to connect you now okay. Hi good morning my name is ******* (talking to DP). Just give me one moment I'm going to try to connect you now. Okay. Mr. ********?*
07:05:28	Captain	*Okay.*
07:05:31	Operator	*Okay, one moment please. Thank you for waiting.*

Time	Person	Statement
07:05:52	Captain	*Oh God.*
07:05:54	Operator	*Just briefly what is your problem you're having?*
07:05:59	Captain	*I have a marine emergency and I would like to speak to a QI. We had a hull breach, a scuttle blew open during a storm we have water down in 3 hold with a heavy list. We've lost the main propulsion unit; the engineers cannot get it going. Can I speak to a QI please?*
07:06:21	Operator	*Yes, thank you so much, one moment.*
End		

[a]QI = qualified individual. 33 CFR 155.1026, Qualified individual and alternate qualified individual. (a)must identify a QI and at least one alternate. In his interviews, the designated person (ashore) identified himself as the QI. The qualified individual or alternate qualified individual must be available on a 24-hour basis. TOTE has three named senior employees a primary QI; and two named contract employees of Gallagher Marine Systems as Alternate QI.
* Unintelligible word; # expletive; @ nonpertinent word, in most cases, an individual's name; ( ) questionable insertion – the group either could not agree or was uncertain of a spoken word or phrase; [ ] editorial insertion.

VDR Transcript of Captain's Conversation with DP

Table 1 of the survival group chairman's factual report is the call center's recording on October 1, 2015, of the *El Faro* captain's conversation with the operator as she was connecting him to the DP. *El Faro*'s VDR recorded the captain's part of his conversation with the DP, starting at 0706 EDT. The DP's part of the conversation was not recorded by the VDR. Table A1-2 reproduces the transcription from the VDR of the conversation between the captain and the DP.[3]

Table A1-2. Captain's conversation with DP on October 1, 2015, from VDR transcript.

Time	Person	Statement
07:06:56.2	Captain	Hello this is @CAPT [Name, first - middle initial - last.] master. yes this is @CAPT [Name, first - middle initial - last.] on the El Faro whom am I speaking with?
07:07:06.9	Captain	Hello captain @DP– captain @CAPT.
07:07:09.7	Captain	Sir.
07:07:11.6	Captain	A sc–

[3] NTSB electronic data group chairman's VDR audio transcript, pp. 474–480.

Time	Person	Statement
07:07:15.4	Captain	Yea. I'm real good. We have uhh– secured the source of the water coming in to the vessel. Uh a scuttle– was blown open uh– by the force of the water perhaps– no one knows. Can't tell. Uh it's since been closed. However– uh– three hold's got considerable amount of water in it. Uh we have a very– very– healthy port list. The engineers cannot get lube oil pressure on the plant therefore we've got no main engine. And let me give you um a latitude and longitude. I just wanted to give you a heads up before I push that– push that button.
07:08:03.6	Captain	Our position is– latitude twenty-three degrees twenty-six point three minutes north– longitude– zero-seven-three degrees fifty-one decimal six west.
07:08:25.9	Captain	Yup. The– the crew is safe. Right now, we're tryin' to save the ship (now). But uh all available hands.
07:08:36.4	Captain	We are forty-eight miles east of San Salvador.
07:08:44.2	Captain	We are taking every measure to take the list off. by that I mean pump out that pump out that hold the best we can but we are not gaining ground at this time.
07:09:01.1	Captain	Uhhh.
07:09:05.2	Captain	Right now, it's a little hard to tell because all the wind is that on that side too so we got a good wind heel goin'.
07:09:11.9	Captain	But it's not gettin' any better.
07:09:16.0	Captain	And I'm gunna guess uh– yeah um– I'm– I'm– go 'head sir go 'head– go 'head.
07:09:23.7	Captain	Alright um– priorities. We um– gunna– gunna stay with the ship there na– no one's panicking um everybody's been made aware. Um our– our safest bet is to stay with the ship during this particular time– the weather is ferocious out here. And uhh– we're– we're– gunna stay with the ship. Now as– go 'head sir.
07:09:54.6	Captain	Right. The uh– state of the weather.
07:10:08.4	Captain	(The) swell is out the northeast.
07:10:15.6	Captain	A solid– solid ten to twelve feet (over) spray high winds very poor visibility that's the best I can give ya right now– I'll give ya a barometric pressure.
07:10:49.2	Captain	Uh…
07:10:51.8	Captain	Betcha it's all of fifteen– fifteen degrees.
07:10:59.3	Captain	Ten. ten to fifteen degrees but a lot of that's with the wind heel.
07:11:10.5	Captain	(I can't) can't determine that at this time 'cause (three) *.
07:11:24.9	Captain	That that is correct. The engine room has informed me that they are pumping that hold. There's a significant amount of water in there.
07:11:47.6	Captain	That's correct.
07:11:59.7	Captain	yup what– what– I wanted to do I wanna push that button– I wanna push that S-S-A-S button– I wanna send some alarms (in/on) our G-M-D-S-S console. I wanna wake everybody up.

Time	Person	Statement
07:12:16.0	Captain	Okay. I– I just wanted to give you that courtesy so you wouldn't be blindsided by it and have the opportunity– everybody's safe right now we're in survival mode now.
07:12:29.6	Captain	Yup. Thank you, sir.
End		

* Unintelligible word; # expletive; @ nonpertinent word, in most cases, an individual's name; ( ) questionable insertion – the group either could not agree or was uncertain of a spoken word or phrase; [ ] editorial insertion.

As the captain concluded his call with the DP at 0712, he told the second mate to send the distress messages that she had prepared earlier (at 0638) to report flooding, cargo adrift, time, and position. At 0713, the second mate reported that the distress buttons (Inmarsat-C and SSAS) had been pressed and the distress alert completed, but she showed a message sent/send fail alert for the text of the (Inmarsat-C) message that she had typed.

Distress Communications

Table A1-4. *El Faro* distress communications, October 1, 2015.

Type	Time	From	To	Position	Time	Course	Speed
Phone call	0706	*El Faro*	DP	23° 26.3'N, 073° 51.6'W	0708	n/a	n/a
Inmarsat-C	0715	LES Norway	Coast Guard	23.28N, 073.48W	11:13:21 (UTC)	n/a	n/a
SSAS	0715	LES Norway	Coast Guard	23:25.39N, 073:52.51W	11:13:49 (UTC)	214°	04 knots
SSAS	0717	LES Norway	TOTE	23:25.22N, 073:52.68W	11:15:57 (UTC)	227°	10 knots
EPIRB	0739	USMCC	Coast Guard	Unlocated	1136 (UTC)	n/a	n/a

NOTE: Latitude and longitude in the table are displayed differently. However, all positions are to be read in degrees, minutes, and fraction of a minute (DDD MM.mm).
Phone call position was spoken as navigator's plot positions on a chart: in degrees, minutes, and a tenth of a minute (DDD° MM.m'). Inmarsat-C position has a decimal "." between degrees and minutes. There was confusion about whether the position was to be read as degrees and a fraction of a degree (DDD.dd), but it was confirmed with LES Norway that the position is to read as degrees and minutes (DDD.MM). SSAS position has a colon ":" to separate degrees from minutes. It is also read as DDD:MM.mm.

EPIRB Positioning by Medium Earth Orbit Satellites

Section 5.16 in the survival factors report, which discusses the experimental medium earth orbit (MEO) satellite system, should have contained the information in table A1-5. The table shows that two local user terminals (GEOLUTs) from two Geostationary Operational Environmental Satellites (MD1/GOES-East and MD2/GOES-West) intermittently detected transmissions from *El Faro*'s EPIRB during the 24 minutes from 1135 to 1159 UTC (0735 to 0759 EDT). During this time, the EPIRB made 30 transmissions—one burst every 50 seconds. Each GEOLUT detected 13 bursts from the EPIRB; however, not all the detected bursts were the same bursts, and 10 bursts were not detected by either GEOLUT.

Table A1-5. MD1 / GOES-E data—13 bursts; MD2 / GOES-W data—13 bursts[4]

Burst	Time (UTC)	MD1	MD2
1	10/01/15 11:35:05.000	1	
2	10/01/15 11:35:55.000		
3	10/01/15 11:36:45.000	1	1
4	10/01/15 11:37:35.000	1	
5	10/01/15 11:38:25.000	1	
6	10/01/15 11:39:15.000	1	
7	10/01/15 11:40:05.000	1	1
8	10/01/15 11:40:55.000		1
9	10/01/15 11:41:45.000	1	
10	10/01/15 11:42:35.000		1
11	10/01/15 11:43:25.000		1
12	10/01/15 11:44:15.000		
13	10/01/15 11:45:05.000	1	

[4] US SARSAT engineering report on MV *El Faro* incident, October 1, 2015 (NOAA, Suitland, Maryland, 2016), p. 3.

14	10/01/15 11:45:55.000	1	1
15	10/01/15 11:46:45.000		
16	10/01/15 11:47:35.000		1
17	10/01/15 11:48:25.000		
18	10/01/15 11:49:15.000		
19	10/01/15 11:50:05.000		1
20	10/01/15 11:50:55.000		
21	10/01/15 11:51:45.000	1	1
22	10/01/15 11:52:35.000		1
23	10/01/15 11:53:25.000		1
24	10/01/15 11:54:15.000		
25	10/01/15 11:55:05.000		
26	10/01/15 11:55:55.000		
27	10/01/15 11:56:45.000		
28	10/01/15 11:57:35.000	1	
29	10/01/15 11:58:25.000	1	1
30	10/01/15 11:59:15.000	1	1

Global Maritime Distress and Safety System

The Global Maritime Distress and Safety System (GMDSS) provides communication support for global search and rescue, based on a combination of satellite and terrestrial radio services. At the time of the accident, GMDSS had changed distress communication from being primarily ship-to-ship to ship-to-shore, using rescue coordination centers. Before GMDSS, ships carried communication equipment by tonnage. GMDSS required ships to carry communication equipment based on the areas where they operate. *El Faro*'s Coast Guard certificate of inspection stated that the vessel was approved for "oceans" as its permitted route. GMDSS defined four sea

areas[5] to describe where GMDSS services were available and to establish the radio equipment GMDSS-equipped ships must carry. Sea area A3 is the "oceans" waters of the GMDSS. According to 47 CFR 80.1091, *El Faro* was required to carry the following GMDSS equipment:

- Very high frequency (VHF) radios capable of operating by voice and transmitting on digital selective calling (DSC).
- Two search and rescue transponders (SART).
- Three GMDSS VHF-FM handheld radios.
- Maritime safety information (MSI) receiver capable of receiving navigational text (NAVTEX) urgent marine safety information, navigational and meteorological warning and forecasts messages.
- Category 1 406 MHz EPIRB.
- Medium frequency (MF) installation with 2187.5 kHz DSC capability.
- Inmarsat ship earth station.

On January 27, 2015, an annual survey and testing of GMDSS equipment was performed on *El Faro* by Imtech Marine Services, Inc. The vessel's Cargo Ship Safety Radio Certificate was issued on January 27, 2015. The certificate affirmed that the *El Faro* had the required GMDSS equipment on board in working order in accordance with the requirements of SOLAS.

Incorrect Last Known Position, Coast Guard Search and Rescue Planning System

The email from LANTWATCH to D7CC ("Inmarsat C Distress: Distress info *El Faro*, 48NM East of San Salvador") had two positions (23-26.3N, 073-51.6W, 48 nm east of San

[5] The United States has no sea area A2 service; the Coast Guard closed it on August 1, 2013. *GMDSS Areas and Search and Rescue Areas*, Coast Guard Navigation Center, downloaded June 13, 2017 https://www.navcen.uscg.gov/?pageName=gmdssArea.

Salvador) that the DP passed to LANTWATCH. The other position was the Inmarsat-C distress alert from *El Faro* (23.28N, 73.48W). According to the Coast Guard, the Inmarsat C distress position passed by LANTWATCH was used as the official last known position (LKP) for documentation in the Marine Information for Safety and Law Enforcement (MISLE) database and for search planning in the Coast Guard's Search and Rescue Planning System (SAROPS). This position was entered by the Coast Guard watch at D7CC. Inmarsat-C distress alert position of 23.28N 73.48W (as shown on the Inmarsat C information sheet) was converted (automatically) by SAROPS to 23-16.8N 073-28.8W. The converted SAROPS position was off by approximately 23 miles compared with the LKP passed by the DP, SSAS position (not provided in LANTWATCH email) and the Inmarsat C position when correctly interpreted as degrees and minutes. The Coast Guard determined that when 23.28N, 73.48W (in degrees and minutes, DD.MM) was entered in that specific format, SAROPS interpreted the position as whole degrees to the 1/100 degree (DD.dd) and converted it to degrees, minutes to 1/10 minute (DD.MM.m).[6]

Factual Report Table 10 (corrected)

Table 10 in the survival factors report was reproduced from *El Yunque*'s station bill. The table below is a representation of the *El Faro* station bill received from TOTE. The station bill provided was an electronic copy of the station bill previously copied from the chief mate's computer. The recentness of the electronic copy of *El Faro*'s station bill provided to investigators is not known.

Table 10 (corrected). *El Faro* crewmember assignments for emergency and abandon-ship duties from station bill.

[6] "D7 El Faro Initial Position Report," PowerPoint brief, January 18, 2017, USCG CGD17.

Billet	Emergency	Abandon ship
Deck Department		
MASTER	In Command all Operations, GMDSS	Lifeboat #1, In Command
CHIEF MATE	In Charge at the Scene	Lifeboat #2, In Command
SECOND MATE	In Charge of Muster, then report to Bridge	Lifeboat #1, Second In Command, LB Radio / SART / EPIRB
THIRD MATE	Leader Emergency Squad #2	Lifeboat #2, Second In Command
BOSUN	Leader Emergency Squad #1	Lifeboat #2 Brake / Winch Operator
AB MAINT #1	Emergency Squad #2	Lifeboat #1 Assist as Directed
AB MAINT #2	Emergency Squad #1	Lifeboat #2 Assist as Directed
AB 12 x 4	Relieve the Helm	Lifeboat #1 Assist as Directed
AB 4 x 8	Emergency Squad #2	Lifeboat #1 Assist as Directed
AB 8 x 12	Emergency Squad #1	Lifeboat #2 Assist as Directed
DECK GUDE	Emergency Squad #2	Lifeboat #1 Assist as Directed
DECK CADET #1	Report to Crew Mess and Assist as Directed	Lifeboat #1 Assist as Directed
DECK CADET #2	Report to Crew Mess and Assist as Directed	Lifeboat #2 Assist as Directed
Engine Department		
CHIEF ENGINEER	Engine Room, In Charge	Lifeboat #1 Assist as Directed
FIRST ENGINEER	Assist as Directed in Engine Room	Lifeboat #2 Assist as Directed
SECOND ENGINEER	Assist as Directed in Engine Room	Lifeboat #1 Assist as Directed
THIRD ENGR 12 X 4	Remain on Watch or Fire Control Room	Lifeboat #2 Run Motor
THIRD ENGR 8 X 12	Remain on Watch or Fire Control Room	Lifeboat #2 Assist with Motor
ELECTRICIAN	Run Emergency Diesel Generator and/or Assist Chief Mate at Scene	Lifeboat #1 Brake / Winch Operator
OMU 12 x 4	Remain on Watch or Report to Crew Mess and Assist	Lifeboat #2 Assist as Directed
OMU 4 x 8	Remain on Watch or Report to Crew Mess and Assist	Lifeboat #2 Assist as Directed
OMU 8 x 12	Remain on Watch or Report to Crew Mess and Assist	Lifeboat #1 Assist as Directed
ENGINE GUDE	Emergency Squad #1	Lifeboat #1 Assist as Directed
ENGINE CADET #1	Report to Crew Mess and Assist as Directed	Lifeboat #1 Assist as Directed
ENGINE CADET #2	Report to Crew Mess and Assist as Directed	Lifeboat #2 Assist as Directed
Steward Department		

Billet	Emergency	Abandon ship
STEWARD	Assist with Muster and Report Results to Bridge via Radio	Lifeboat #2 Assist as Directed
CHIEF COOK	Secure Galley, Muster and Assist as Directed	Lifeboat #1 Assist as Directed
STWD ASST	Bridge Messenger, secure all doors up to Bridge	Lifeboat #2, Provide Lifeboat Radio and SART
Supernumeraries		
RIDER #1	Report to Crew Mess and Assist as Directed	Lifeboat #1, bring lifejacket and warm clothing
RIDER #2	Report to Crew Mess and Assist as Directed	Lifeboat #2, bring lifejacket and warm clothing
RIDER #3	Report to Crew Mess and Assist as Directed	Lifeboat #1, bring lifejacket and warm clothing

NOTE: Boatswain, pronounced "bo'sun," is the highest ranking unlicensed billet in the deck department. AB = able seaman. OMU = oiler maintenance utilityman. GUDE = general utility, deck and engine.

Title 46 CFR 199.80 states: "The muster list must be posted before the vessel begins its voyage. After the muster list has been prepared, if any change takes place that necessitates an alteration in the muster list, the master must either revise the existing muster list or prepare a new one."

The same regulations list in paragraph 7: "The duties assigned to members of the crew in relation to passengers and other person on board in case of an emergency. Assigned duties to be specified include—(i) Warning the passengers and other persons on board; (ii) Seeing that passengers and other persons on board are suitably dressed and have donned their lifejackets or immersion suits correctly; (iii) Assembling passengers and other persons on board at muster stations; (iv) Keeping order in the passageways and on the stairways and generally controlling the movements of the passengers and other persons on board."

The same regulations go on to state: "Illustrations and instructions in English, and any other appropriate language as determined by the Officer in Charge, Marine Inspection (OCMI), must be posted in each passenger cabin and in spaces occupied by persons other than crew, and must be conspicuously displayed at each muster station. The illustrations and instructions must include information on (1) The fire and emergency signal; (2) Their muster station; (3) The essential actions they must take in an emergency; (4) The location of lifejackets, including child-size lifejackets; and (5) The method of donning lifejackets."

Differences in Lifeboats and Launching Methods

Table 12, "Survival craft systems on US-inspected vessels (07-Oct-2016 USCG)," of section 5.17, "International Lifeboat Standards and Regulations," in the survival factors factual report shows the numbers of pre-1986 open lifeboats, side-launched (146); post-1986 enclosed lifeboats, side-launched (72); and enclosed life capsules, freefall-launched (34). Both open and enclosed lifeboats are launched by gravity davits; there is no difference in launching. The differences between an open lifeboat and an enclosed lifeboat launched by gravity davits when launched are as follows: an enclosed lifeboat has reserve buoyancy when the doors and ports are closed (watertight); an enclosed lifeboat protects the occupant from exposure to the elements—storm conditions and the sun. A water spray system and air supply can be fitted to protect the occupants from fire and smoke.[7]

The need for a freefall lifeboat launching system came about in 1988 after the *Piper Alpha* oil platform exploded in the North Sea. Many workers were killed, and a safer evacuation system

[7] *Escape! Pioneers of Survival*, Public Broadcasting Service (PBS) NOVA, downloaded May 22, 2017, at http://www.pbs.org/wgbh/nova/escape/pioship html.

from heights over 100 feet was needed. Freefall lifeboats have the same equipment requirements as side launch enclosed life boats, and provide similar protections as far as exposure to elements. They have reserve buoyancy when doors and ports are closed. They are also required to be able to be launched at 20 degrees list and 10 degrees trim. The main difference is that there are no davits, and when launched the free fall lifeboats end up some distance from the vessel.

Lifeboat Manufacturer Witness

A representative of the lifeboat manufacturer was interviewed at the NTSB on October 13, 2016, and he testified at the third Coast Guard MBI on February 15, 2017. He was the operations director who oversaw service and after-sales support of lifesaving equipment. He had been a Bahamian coast guard officer; represented several maritime administrations as a marine inspector and surveyor, including the Bahamas, Malta, Isle of Man, Cayman Islands, Dominica, and Bermuda; was a principal surveyor at Lloyd's Register, where he was the global head for lifesaving appliances from 2002 to 2008 and had oversight for contribution to the International Life-Saving Appliances (LSA) code; was the development manager for Lloyd's Register North America; was a country manager for a survival systems company; and had investigated at least 30 lifeboat-related accidents. He had 20 years' experience in the maritime industry and held a bachelor of science degree in naval architecture and marine engineering, and a master's degree in maritime operations and management.

The changes in the design standard for lifesaving appliances were agreed on in the early 1980s, but the requirements did not come into force until 1986. The requirements included the phasing out of open lifeboats, which the maritime industry recognized as subpar. The design requirements for a modern enclosed lifeboat include self-righting, damage testing, reserve

buoyancy, and engine propulsion. Modern lifeboats are enclosed and are either launched conventionally, using twin fall davits down the side of a vessel and on-load release hooks, or they are launched freefall from a cradle. At the time of this report, no national maritime administration has banned the use of open lifeboats, and many ships operate today with open lifeboats because they were built before the 1986 rules came into force. SOLAS section III, regulation 31 ("Survival craft and rescue boats"), additional requirements for cargo ships, paragraph 1.5, states, "all survival craft required to provide for abandonment by the total number of persons on board shall be capable of being launched with their full complement of persons and equipment within a period of 10 min from the time the abandon ship signal is given."

The estimated cost to upgrade *El Faro*'s open lifeboats to the modern enclosed design would be about $1 million. Refitting vessels for a stern-launched freefall lifeboat would require reinforcement of the area to accommodate the above-deck launching structure, new stability calculations, and other costly measures.

In an emergency such as a hurricane, the first choice would be to stay aboard the vessel to ride out the storm. Lifeboats were designed to be launched in moderate sea conditions. There is no known successful launching of a lifeboat with survivors under hurricane conditions with winds of 96 to 112 knots, as was the case when *El Faro* sank. According to the lifeboat manufacturer's representative, abandoning ship with liferafts would occur only when no other options were left.[8] [9]

[8] Interview of lifeboat manufacturer operations director at NTSB, October 13, 2016, pp. 52-54.
[9] Testimony of lifeboat manufacturer operations director at MBI-3, February 15, 2017, pp. 1512; 1532-1534.

Traditional side-launched lifeboats are estimated to account for 90 percent of lifeboat accidents and incidents that are investigated, as compared to about 10 percent for freefall lifeboats.

The mosaic photo of *El Faro*'s starboard lifeboat "intact" gravity davits (Figure 21) show the davits in the upright or stowed position, as opposed to the outboard/launch position. The damage to the side of the recovered starboard lifeboat (Figure 17) shows impact damage, which according to the lifeboat manufacturer's representative could have been caused from either the ship or the boat's davits, from falling into the water, or from heavy seas. He further stated that the uniformity of the damage suggests that it may have been caused by the gripes. In the opinion of the manufacturer's representative, on reviewing photos of the davits and the recovered lifeboat, the starboard lifeboat had not been not launched.[10] [11]

The photomosaic of the port lifeboat's "broken" gravity davits (Figure 22) show the davits broken and hanging on the hull below the ship's boat deck. According to the manufacturer's representative, the damage to the port davits was probably caused by impact force from wave action, such as heavy seas at the height of the boat deck. He believed the damage to the port lifeboat, shown on the sea floor in the photomosaic (Figure 20), could have been caused by heavy seas while it was hanging in the falls. One possibility is that the forward release gear held the boat longer, and then the lifeboat fell stern first from a significant height to tear off the lifeboat's stern. Another possibility is that the rolling of the vessel and play in the motion of the lifeboat against the wire gripes cut into the boat's glass reinforced plastic (GRP) and sheared off the stern. The gripes are not load-bearing. The gripes carry a transverse load to keep the boat secured alongside.

[10] Interview of lifeboat manufacturer operations director at NTSB, DC, October 13, 2016, pp. 16, 23, 32.
[11] Testimony of lifeboat manufacturer operations director at MBI-3, February 15, 2017, pp. 1521, 1525.

The load-bearing components of the lifeboat are the loose gear (blocks and wire falls) and the (Rottmer) release gear.[12] The port lifeboat was not launched, according to the representative.[13] [14]

Lifesaving Diagrams

The following figures are added to provide a picture of what is described in sections 5.10 ("Abandon Ship") and section 5.17 ("International Lifeboat Standards and Regulations") in the survival factors factual report.

[12] Interview of lifeboat manufacturer operations director at NTSB, October 13, 2016, pp. 13-15, 18-22.
[13] Interview of lifeboat manufacturer operations director at NTSB, October 13, 2016, pp. 19, 32.
[14] Testimony of lifeboat manufacturer operations director at MBI-3, February 15, 2017, pp. 1525 - 1526.

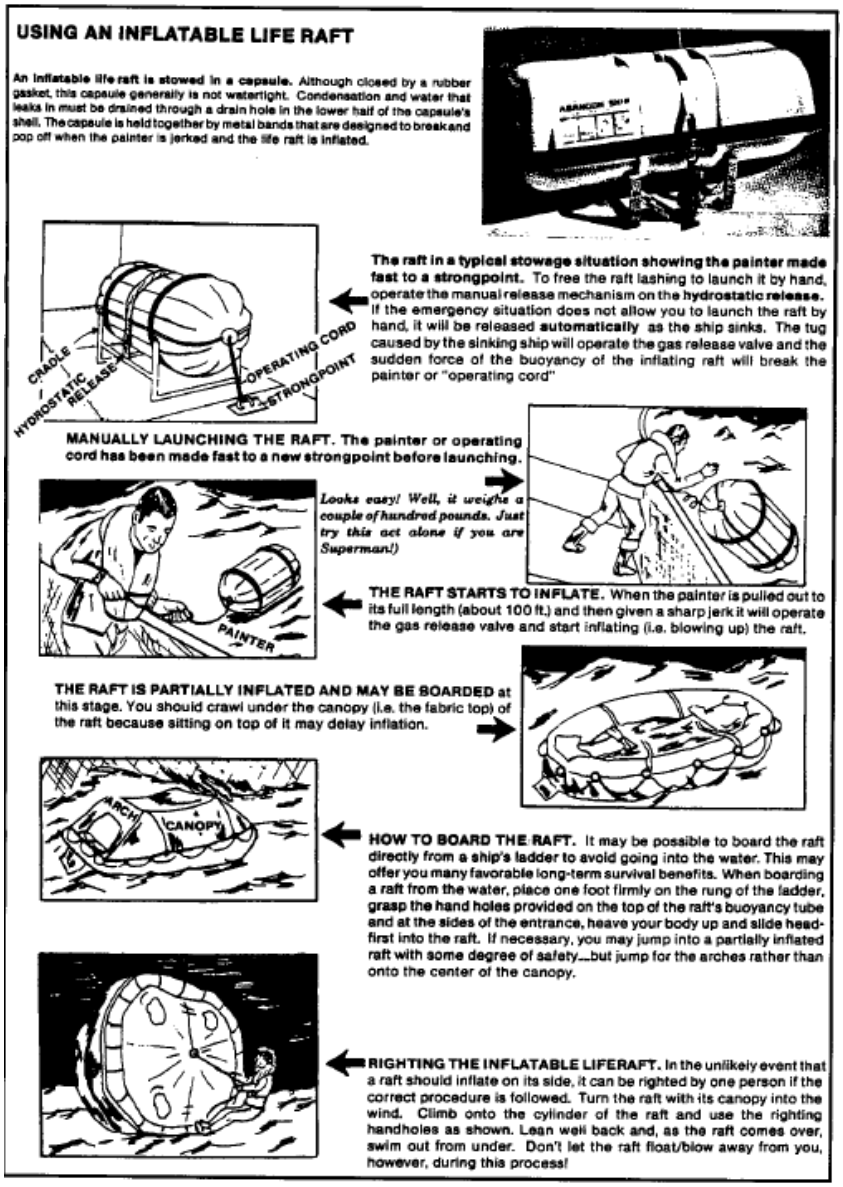

Figure A1-1. Instructions for manual-release liferaft.[15]

[15] *Survival Guide for the Mariner*, p. 78, credit from *Able Seaman and Lifeboatman*, Marine Education Textbooks, Houma, Louisiana, undated. Also see videos downloaded May 22, 2017: *Deploying the SURVIVA Liferaft*, at https://www.youtube.com/watch?v=3SgH8Jv-Ybw; and *Hammar H20 Hydrostatic Release showing how a life raft floats free from a sinking ship*, at https://www.youtube.com/watch?v=pMGXxuEJ4Pw.

VIKING Liferaft throw overboard 25 pers. - 25DK

Item number: L025D000

VIKING 25DK+ liferaft.
Throw overboard type. Stowed in rigid fibreglass container as per attached drawing and approved by DNV in accordance with SOLAS/MED requirements and the relevant flag state approval. Will be delivered complete with emergency pack SOLAS A pack. The 25 persons throw overboard liferaft is mainly used for commercial vessels, passenger vessels and offshore installations. The throw overboard liferaft is released from its cradle and thrown overboard, or slides automatically when released. Once waterborne the liferaft inflates on a hard pull of the painter line and is then ready for boarding.

Figure A1-2. Viking throw-overboard 25-person liferaft.[16]

[16] *Viking Life-Saving Equipment A/S* downloaded May 23, 2017, at https://www.viking-life.com/en/throw-overboard/liferafts-/liferafts-/4860-l000d0002-viking-throw-overboard-liferaft-type-dk-10-25-persons-orange-25-persons; and video *Viking Throw overboard liferaft* at https://vikinglife.23video.com/viking-throw-overboard-liferaft-1.

Figure A1-3. Elliot SOLAS A liferaft (manufacturer RFD-SURVIVA).[17]

[17] *Elliot SOLAS A* Liferaft downloaded May 28, 2017, at https://www.lrse.com/products/elliot-solas-a-life-raft?lssrc=recentviews&lshst=collection and http://survitecgroup.com/survitecproducts/15398/rfd-surviva.

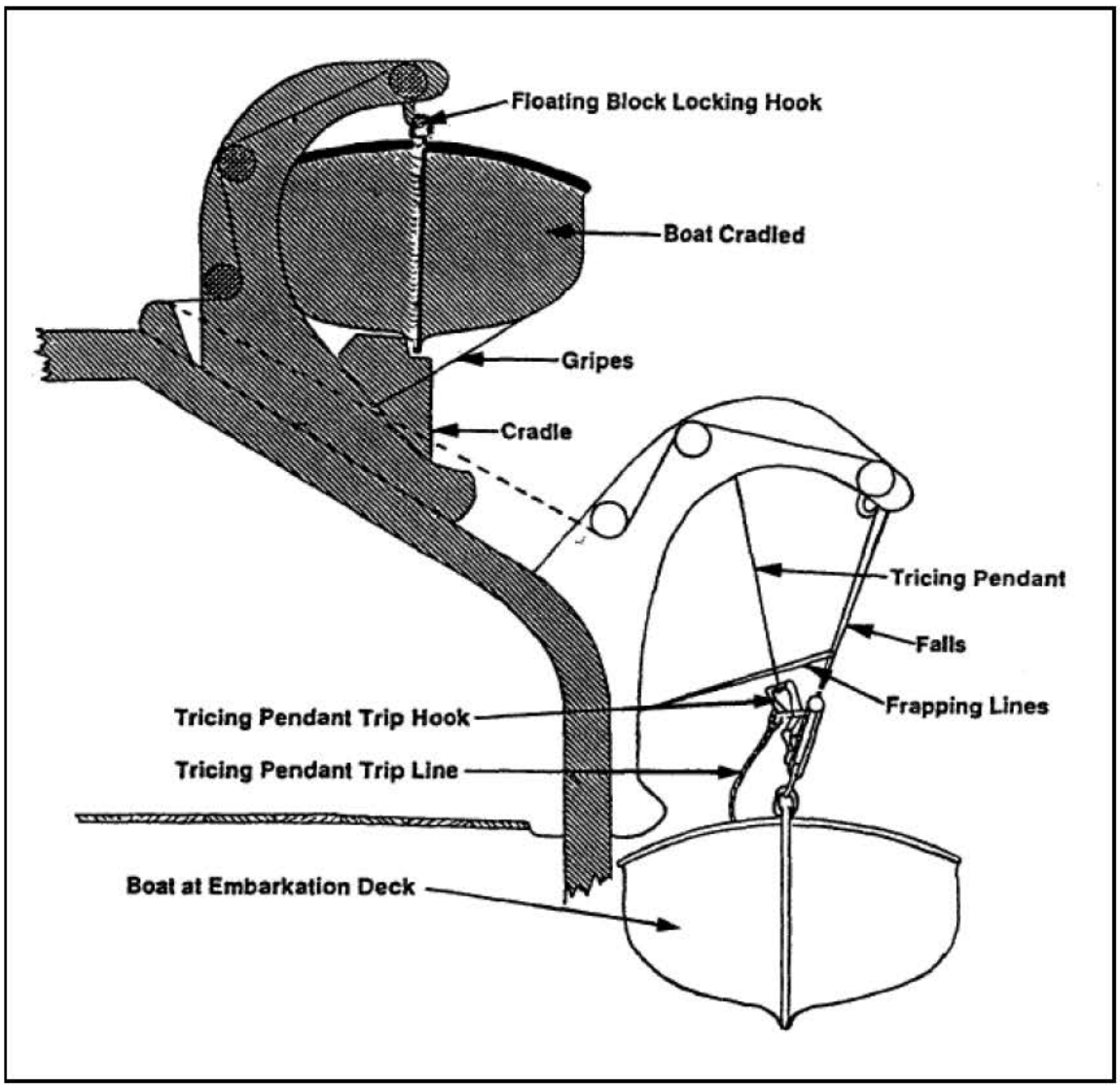

Figure A1-4: Gravity davit (US Coast Guard illustration[18]).

[18] *Survival Guide for the Mariner*. US Coast Guard, p. 70. Also see video *Lifeboat drill on Weather Ship VOLNA, North Atlantic, April 1990*, downloaded May 22, 2017, at https://www.youtube.com/watch?v=9JHAuJdk0cQ.

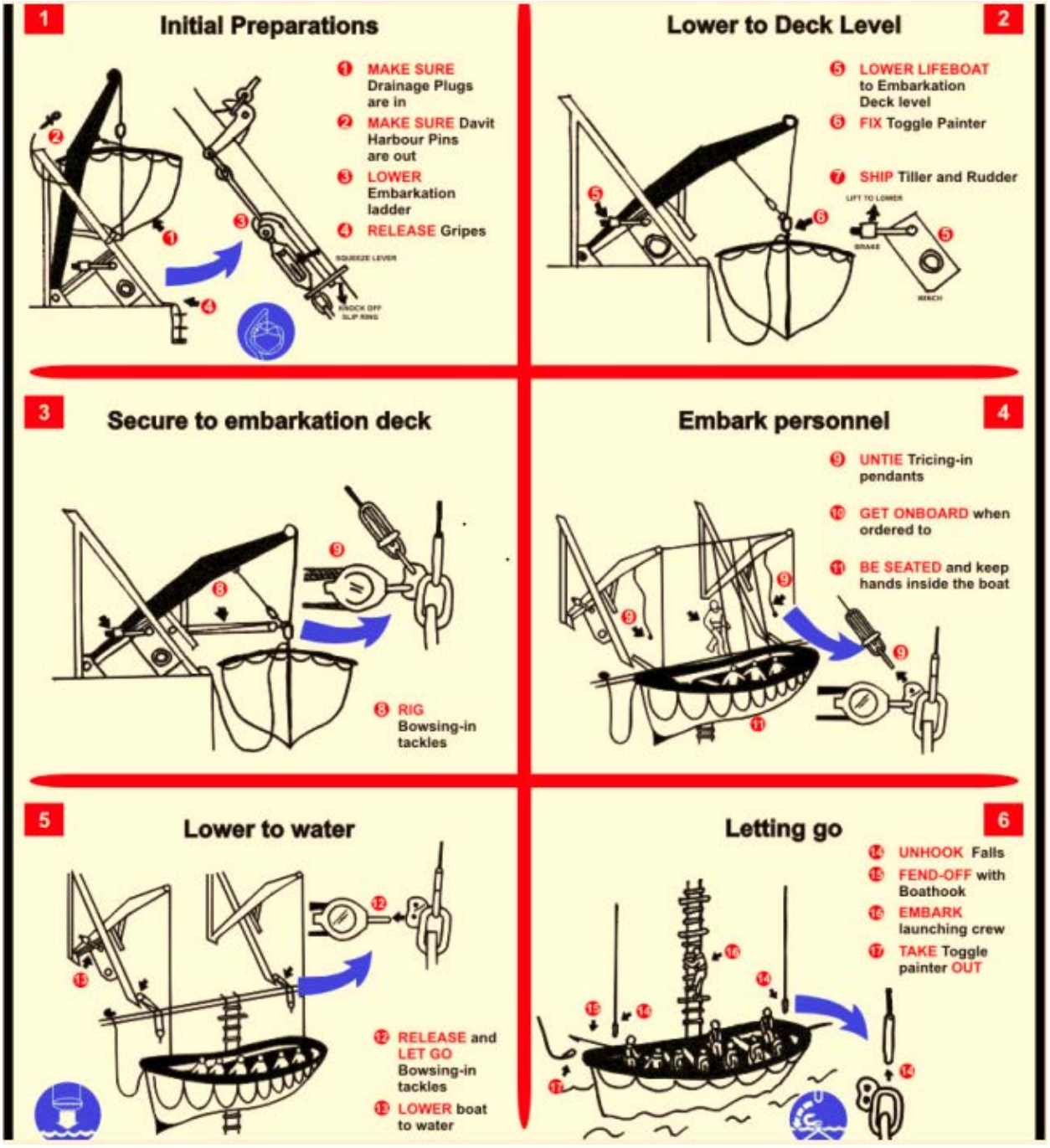

Figure A1-5. Instructions for launching a lifeboat with gravity davits[19] (same procedure for open and enclosed lifeboats launch with gravity davits).

[19] *Lifeboat Launching Order/Full Procedure Step by Step*, downloaded on June 14, 2017 at http://marineinfobox.blogspot.com/2017/05/lifeboat-launching-order-full-procedure.html; image credit and source imostickers.com

Figure A1-6. Stern-launched freefall lifeboat. Palfinger Marine (Harding) LBF 850 freefall lifeboat (dry cargo or tanker version), maximum seating 40 persons, tested to a maximum drop height of 82 feet (Palfinger Marine[20]).

[20] *Palfinger Marine Freefall Lifeboats* and *Harding Product Catalog 2016*, downloaded June 20, 2017, at https://www.palfinger.com/en/marine/products/lifesaving-equipment/life-and-rescue-boats/free-fall-lifeboats

Figure A1-7. Free fall lifeboat launching (Prime Products Distribution[21])

[21] *Free Fall Lifeboat Launching,* Prime Products Distribution, downloaded May 22, 2017, at http://primeltd.com/category/159/products/1530. Also see video, *Launching and Recovery System of Free Fall Lifeboats,* Maritime Trainer downloaded May 22, 2017, at https://www.youtube.com/watch?v=fTvDJHyctH0.

Safety Drills–Last Abandon Ship Drill

Electronic fire and emergency drill log sheets were submitted by the company for the second and third quarters of 2015 during the technical review of this report. The company obtained the partial third quarter 2015 documents from a crewmember who made copies of records from the chief mate's computer prior to his departure from *El Faro* on September 18, 2015. It is unknown if drills were held after this date and before the vessel sinking. The third-quarter logs were unsigned electronic documents and show *El Faro*'s weekly fire and emergency drills were held on: September 10 (electronic list of 25 crew); August 20 (electronic list of 25 crew); August 6 (electronic list of 25 crew); July 23 (electronic list of 25 crew); July 16 (electronic list of 25 crew); July 9 (electronic list of 25 crew); July 2 (electronic list of 25 crew). The second-quarter logs were signed by *El Faro*'s crew on the first page; and by the deck cadet, the engine cadet, and a supernumerary reefer engineer or steward on the second page. *El Faro*'s second-quarter weekly fire and emergency drills were held on June 4 (28 signatures), June 5 (9 signatures starboard lifeboat in the water San Juan, Puerto Rico, with Fleming gear exercised); May 14 (first page 25 on electronic list and second page with 3 signatures), and May 7 (28 signatures). None of these log sheets contained the American lead supernumerary or any of the Polish supernumerary/riding crew names or signatures.

El Faro's last recorded fire and emergency drill was conducted on September 10, 2015 at 1520. The unsigned electronic log sheet listed the name of 25 crewmembers for a fire drill, followed by an abandoned-ship drill. The electronic log sheet stated that the following training topics were covered:

- Class "A" fire reported from officers' spare room. Crew musters on fire teams suit up. Both teams fight fire and conduct fire nozzle training.

- Abandon-ship signal sounded. Crew mustered at the lifeboat stations. Lifeboats #1 and #2 lowered to the embarkation deck. Crew instructed on their duties.
- Following drill crew conducts debrief for lessons learned.

As stated in the survival factors report, the last *El Faro* deck logbooks submitted to the TOTE safety office was for August 2015. The deck logbooks show that a fire/emergency drill was conducted on Thursday, August 27, 2015. The abandon-ship drill was not conducted that day due to weather conditions caused by tropical storm Erika.

The last abandon-ship drill for the month of August was conducted on August 20. An email ("Fire and Boat Drills Today 20 Aug 2015 at 1020") was stapled to the deck log page. According to the email, the chief mate sounded the "fire and emergency drill" at 1020, on completion of the fire and emergency drill, which consisted of the following:

1. Sound Abandon Ship Signal on Ship's Whistle and General Alarm.
2. Crewmembers report to their station with Life Jackets / Immersion suits and hard hats.
3. Take / Report Muster to Bridge.
4. Boat Commanders review duties and Life Boat Launching procedures.
5. Boat Commanders review Life Raft Launching procedures.
6. When finished, notify Master and secure from Abandon Ship Drill.
7. Upon completion of the Abandon Ship Drill all available hands report to the Crew's Mess for ISM Training / SOLAS Training.

The following entries were made in the deck logbook for August 20:

- 1020 Fire in crew laundry (See attached sheet for details of drill).

- 1050: Pos. L22°38.8'N λ071°07.2'W tested Em. lifeboat radios (3), SARTs (2), 406 MHz EPIRB. All satisfactory per 46 CFR 199(e)(2).

The company's "Safety Inspection Equipment Testing Log" for 2015 used on *El Faro* stated that the reference for the required weekly fire and boat drills was 46 CFR 199.180(c). *El Faro*'s deck logbook on July 16 had the standard entry for weekly drills "1520—F(ire) & B(oat) drill checklist 16L completed." The company's "16L Fire and Boat Drills Checkoff List" contained 16-line items:

1. Bridge, Master and engine room informed of drill intentions.
2. Nearby traffic or terminal notified of drill intentions.
3. Drill scenario discussed with team leader prior to drill.
4. Record position of vessel in deck logbook.
5. Sound appropriate signals on whistle and general alarm bells (all hands must report with hard hats & life jackets).
6. Switch vessel to hand steering and standby engines.
7. Maneuver vessel to bring relative wind to a favorable direction, if underway.
8. Muster crew members at assigned locations as per station bill.
9. Establish radio communications between Emergency & Support Parties, E/R & Bridge.
10. Advise Radio Officer (if carried) of vessel position in preparation for SOS message.
11. Breakout & demo. Appropriate lifesaving and firefighting equipment for drill scenario.
12. Conduct drill scenario as appropriate for [the] particular drill [scenario].
13. Inspect condition of all equipment used and enter statement of condition in deck log.
14. Re-stow all equipment properly.
15. Critique drill with Emergency and Support Parties.

16. Secure from drill and make appropriate logbook entries.

Title 46 CFR 199.180 (d)(4)(v) requires "each lifeboat must be launched with its assigned operating crew aboard and maneuvered in the water at least once every 3 months during an abandon ship drill." According to the *Safety Drills – Quarterly Logsheet* for the 2nd quarter of 2015, dated June 30, 2015, the starboard lifeboat was lowered to the water and released on June 5, 2015 at 0900 to 0930, in San Juan. The signed muster sheet indicates that nine crewmembers, led by the chief mate, participated in the operational training, "training topics covered: conducted safety drill of quarterly starboard lifeboat lowering. Starboard lifeboat lowered to the dock in San Juan, PR and placed into cradle, brake tested during lowering, releasing gear exercised, Fleming gear exercised, and limit switches tested on recovery. All in good order." According to the same 2nd quarter logsheet, the port lifeboat lowered to the water and released on April,17, 2015. The port lifeboat was also lowered into the water during a drill was on March 6, 2015, in San Juan harbor, for a Coast Guard annual exam and fire and abandon-ship drill. The Coast Guard inspector stated that the port lifeboat was lowered to the embarkation deck and that the sheaves and brakes were checked. The boat was stopped while it was being lowered to make sure the brakes held. The inspector stated that the crew was competent in the drills, that the crewmembers knew their jobs, and the radio communication was good. The inspector checked the manual Fleming gear on the starboard lifeboat, that the liferafts were properly stored, and that the service tags matched the Coast Guard's records. The inspector stated that the crew mustered in lifejackets and that he spot-checked crewmembers' survival suits.[22]

Personal Lifesaving Appliance Requirements

[22] Interview of Coast Guard civilian inspector at San Juan, Puerto Rico, October 10, 2015, pp. 48-67.

Certain requirements for lifesaving appliances apply to all inspected vessels. Regulations at 46 CFR 190.70(b) require vessels to carry lifejackets for each person onboard. Enough lifejackets must be carried for persons on watch and for use at remotely located survival craft stations. The stowed lifejackets must be readily available. The additional lifejackets for persons on watch must be stowed on the bridge, in the engine control room, and at other manned watch stations.

Additional requirements apply to cargo vessels. Regulations at 46 CFR 199.273 require cargo vessels to carry immersion suits, like the lifejacket requirements. However, cargo vessels that operate only on routes between 32° north and 32° south are exempt from the requirement to carry immersion suits. *El Faro*'s route from Jacksonville, Florida, to San Juan, Puerto Rico, was within the exempted zone. On its return to the Alaska run, *El Faro* would have been required to carry immersion suits.

Lifesaving Systems Requirements for All Vessels

Regulations at 46 CFR 199.30 define a passenger as any individual carried onboard a vessel on other than an international voyage "except (1) the owner or an individual representative of the owner/charterer; (2) the master; or (3) a member of the crew engaged in the business of the vessel who has not contributed consideration for carriage and who is paid for onboard services."

Muster list and emergency instruction regulations at 46 CFR 199.80 state: "(a) *General*. clear instructions must be provided on the vessel that detail the actions each person on board should follow in the event of an emergency. (b) *Muster list*. Copies of the muster list must be posted in conspicuous places throughout the vessel including on the navigating bridge, in the engineroom, and in crew accommodation spaces. The muster list must be posted before the vessel begins its

voyage. After the muster list has been prepared, if any change takes place that necessitates an alteration in the muster list, the master must either revise the existing muster list or prepare a new one. Each muster list must at least specify— (1) the instructions for operating the general emergency alarm system and public-address system; (2) the emergency signals; (3) the actions to be taken by the persons on board when each signal is sounded; (4) how the order to abandon the vessel will be given. . . . (6) the duties assigned to the different members of the crew. Duties to be specified include — (v) mustering the passengers and other persons on board. . . . (7) The duties assigned to members of the crew in relation to passengers and other person on board in case of an emergency. Assigned duties to be specified include—(i) warning the passengers and other persons on board; (ii) seeing that passengers and other person on board are suitably dressed and have donned their lifejackets or immersion suits correctly; (iii) assembling passengers and other person on board at muster stations; (iv) keeping order in the passageways and on the stairways and generally controlling the movements of the passenger and other persons on board — (c) *Emergency instructions*. Illustrations and instructions in English, and any other appropriate language as determined by the OCMI, must be posted in each passenger cabin and in spaces occupied by persons other than crew, and must be conspicuously displayed at each muster station. The illustrations and instructions must include information on — (1) the fire and emergency signal; (2) their muster station; (3) the essential actions they must take in an emergency; (4) the location of lifejackets; and (5) the method of donning lifejackets."

Training and drill regulations in section 199.180 state at paragraph (c)(2): "Every crewmember must participate in at least one abandon-ship drill and one fire drill every month. The drills of the crew must take place within 24 hours of the vessel leaving a port if more than 25 percent of the crew have not participated in abandon-ship and fire drills on board that particular

vessel in the previous month." Paragraph (d)(1) states that abandon-ship drills must include "(i) Summoning persons on board to muster stations with the general alarm followed by drill announcements on the public address or other communications system and ensuring that the persons on board are made aware of the order to abandon ship; (ii) Reporting to stations and preparing for the duties described in the muster list; (iii) Checking that persons on board are suitably dressed; (iv) Checking that lifejackets or immersion suits are correctly donned; (v) Lowering of at least one lifeboat after any necessary preparation for launching; (vi) Starting and operating the lifeboat engine; and (vii) Operating davits used for launching the lifeboats."

Supernumerary MBI Witness

A Polish electrician, with the assistance of translators, testified at the third Coast Guard MBI on February 15, 2017.[23] He was a supernumerary on *El Faro* from August 18 through September 29, 2015, and worked on electric cables for the cargo ramps. He had 10 weeks' experience at sea working on a Holland-American Line vessel before working on *El Faro*. The Polish supernumeraries reported aboard and went directly to the captain's office to fill out forms. The electrician testified that they were unaware that it was hurricane season, and he could not recall a safety briefing or emergency instructions in either English or Polish. The American supernumerary chief engineer took the Polish supernumeraries around *El Faro* to show them what work was to be done and where to do it. One of the Polish supernumeraries spoke English and would translate for the rest of the supernumeraries. The witness said they were provided with personal protective equipment, but were not given safe work instructions. The Polish

[23] Testimony of former supernumerary Polish electrician at MBI-3 Jacksonville, Florida, February 15, 2017, transcript pp. 1419-1450.

supernumeraries worked seven days a week from 0700 to 1900 and according to the witness had limited interaction with the ship's crew.[24]

When asked if he was given a safety briefing and shown the lifeboats, life jackets and immersion suits, the witness stated that he could not remember. He said that he saw "some items in the closets on the ship. Some of them were vests. He saw some emergency boats. But he doesn't know any details more or less." They were not assigned to lifeboats or briefed on what to do in case of an actual abandon-ship event or abandon-ship drill. They did not know where the muster station was located. They did not know the difference between the emergency and abandon-ship alarms. When the crew mustered for drills once a week, the Polish supernumeraries kept on working and did not participate in the drills, according to the witness.[25] [26]

The Polish electrician said he could not recall the condition of the scuttles on *El Faro*, but that the watertight door that led to the engine room on the third deck on *El Faro* was open between 0700 to 1900 and may have been secured at night. The Polish supernumeraries believed that the overall condition of *El Faro* was poor, based on the amount of rust.

During tropical storm Erika, the Polish supernumeraries were not specifically asked to secure their equipment, said the witness, but the equipment was secured at the end of each workday. They were alerted that *El Faro* was taking a different route to avoid Erika. During the storm, they had no safety concerns, according to the witness, and work continued even though storm seas occasionally broke onto the deck where they were working.

[24] Testimony of former supernumerary Polish electrician at MBI-3, February 15, 2017, pp. 1442/1-15.
[25] Testimony of former supernumerary Polish electrician at MBI-3, February 15, 2017, pp. 1426/8-18.
[26] Testimony of former supernumerary Polish electrician at MBI-3, February 15, 2017, pp. 1445/8-16.

Crew MBI Witnesses

Concerning participation in fire and emergency drills by the Polish supernumeraries/riding gang, the following crewmembers testified as follows:

According to the *El Faro* former third/second mate testimony, the captain made sure everyone participated in safety drills and was strict about providing proper indoctrination to the riding crew. The Polish riding gang would muster on the bridge during abandoned ship drills. If individuals, including supernumeraries, did not report to their assigned muster station during drills, the master "turned the drill into a real situation of missing person, missing crew member and we hunt them" until they were found. To the best of his knowledge, the Polish riding gang would muster on the bridge during abandoned ship drills, but did not recall seeing the riding gang near his station.[27]

The *El Yunque* master (*El Faro* former chief mate) stated that new crew members and noncrewmembers undertook a familiarization process of their duties and safety procedures. He believed the third mate was responsible for survival familiarization and would take new crewmembers (and noncrewmembers) and show them their fire station, emergency equipment, and duties. The third mate would show them their lifeboat and abandon-ship duties. On completion of familiarization, the third mate would have the new crewmembers (and noncrewmembers) sign a log acknowledging that they had been indoctrinated.[28] He stated that the supernumeraries' fire drill station was to muster with the crew near the repair locker and to muster at their assigned lifeboat

[27] Testimony of former *El Faro* third and second mate at MBI-3, February 10, 2017, pp. 821-822.
[28] Interview of former El Faro chief mate at NTSB interview, October 7, 2015, pp. 58-62.

and assist as directed for abandon-ship. He could not remember if the Polish supernumeraries took part in drills or put on lifejackets or immersion suits while he was chief mate on *El Faro*.

A riding gang supervisor (also an *El Faro* chief engineer) testified that the riding crew on the *El Faro* participated in the lifeboat drills. When he was assigned to lifeboat #2, there were no Polish riding gang members assigned to lifeboat #2.[29] He was not sure if the Polish riding gang members were given orientation in emergency instructions and lifesaving equipment in their own language. He testified that the Polish riding gang was briefed on liferafts through a translator and could launch a liferaft on their own, but he stated that he was not involved with their training.[30]

A retired TOTE master testified, ship riders that did not speak the English language were given an orientation to make sure they understood the basics of lifesaving equipment issued, and, typically, there was an interpreter or one person that was the primary contact to keep them together. They were also shown their muster location. However, he testified that he worked for TOTE on the west coast from 2007 until he retired in 2015.[31]

An *El Faro* former second mate testified that the Polish riding crew on the El Faro were given an indoctrination when they came onboard, and during fire and boat drills they would muster on the bridge. He was not aware if anyone briefed the Polish supernumeraries on emergency procedures in the event of an emergency during the voyage with tropical storm Erika. When asked if he recalled the Polish supernumeraries participated the drill during Erika he replied, "They would have been mustered, accounted for, but they have no boat responsibilities."[32]

[29] Testimony of former *El Faro* supernumerary supervisor at MBI-1, February 23, 2016, pg. 48/7-13.
[30] Testimony of former *El Faro* supernumerary supervisor at MBI-1, February 23, 2016, pp. 56-57.
[31] Testimony of retired TOTE master at MBI-2, Mary 17, 2016, pp. 26-28.
[32] Testimony of former *El Faro* second mate at MBI-1, February 18, 2016, pg. 67

Water Survival

Normal body temperature is 98.6° F (37° C). Hypothermia occurs when the body loses heat faster than it can produce heat and the body core temperature passes below 95° F (35° C). As core body temperature drops, the heart, nervous system, and other organs stop functioning normally, which can lead to failure of the heart or respiratory system, and death. The body loses heat faster when in water than in air. Water does not have to be extremely cold to cause hypothermia; water that is cooler than normal body temperature causes heat loss.[33] According to the Coast Guard cutter *Northland*'s logs for October 4, 2015, the water temperature in the *El Faro* search area was 85° to 87° F.

Table A1-5. Expected survival time in water, by water temperature.[34]

Water Temperature °F (°C)	Expected Time Before Exhaustion or Unconsciousness	Expected Time of Survival
32.5° (0.3°)	< 15 minutes	45 minutes
32.5–40° (0.3–4.4°)	15 – 30 minutes	30 – 90 minutes
40–50° (3.3–10°)	30 – 60 minutes	1 – 3 hours
50–60° (10–15.6°)	1 – 2 hours	1 – 6 hours
60–70° (15.6–21.1°)	2 – 7 hours	2 – 40 hours
70–80° (21.1–26.7°)	3 – 12 hours	3 hours – indefinite
> 80° (> 26.7°)	Indefinite	Indefinite

[33] *Diseases and Conditions*, "Hypothermia," Mayo Clinic, downloaded December 28, 2016, at http://www.mayoclinic.org/diseases-conditions/hypothermia/basics/definition/con-20020453.

[34] *Hypothermia Prevention: Survival in Cold Water*, "How long can a person survive in cold water?" University of Minnesota Sea Grant, downloaded December 28, 2016, at http://www.seagrant.umn.edu/coastal_communities/hypothermia.

Table A1-6. Situations affecting survival time for average-sized, lightly clothed adult in 50° F (10° C) water.[35]

Situation and Equipment	Predicted Survival Time in 50° F Water
Drown proofing without flotation device	1.5 hours
Treading water without flotation device	2 hours
Swimming with personal flotation device (PFD)	2 hours
Holding still with PFD	2.7 hours
H.E.L.P. position with PFD	4 hours
Huddling with others with PFD	4 hours
With hypothermia-prevention equipment: Insulated flotation jacket (float coat)	3–9 hours
With hypothermia-prevention equipment: immersion suit	Indefinite

The normal human body is about 75 percent water. The major systems of the body need water to function normally and to regulate temperature. Dehydration occurs when the body does not maintain water balance—more water is lost than is replaced. Complications from dehydration include heatstroke, kidney failure, seizures/unconsciousness, and hypovolemic shock (drop of blood pressure and of oxygen in the body).[36]

In simpler terms, the "survival rules of three" state that an average person can survive for the following periods under different circumstances:[37]

- 3 minutes without air–or in icy water.
- 3 hours without shelter in harsh environment–unless in icy water.
- 3 days without water–if sheltered from a harsh environment.

[35] *Hypothermia Prevention: Survival in Cold Water*, "Improving Chances of Survival in Cold Water," University of Minnesota Sea Grant.

[36] *Diseases and Conditions*, "Dehydration," Mayo Clinic, downloaded December 28, 2016, at http://www.mayoclinic.org/diseases-conditions/dehydration/symptoms-causes/dxc-20261072.

[37] "Wilderness Survival Rules of 3–Air, Shelter, Water and Food," *Backcountry Chronicles*, downloaded, December 28, 2016, at http://www.backcountrychronicles.com/wilderness-survival-rules-of-3/.

- 3 weeks without food–if the person has shelter and water.

Probability of Survival Decision Aid

The Coast Guard uses the Probability of Survival Decision Aid (PSDA) for all cases of persons in the water and where persons are at risk of hypothermia or dehydration when not immersed.[38] The PSDA is a reliable means for predicting survival times for cases of hypothermia or dehydration. The survival times are used as guidelines for search planning and case suspension. Figure A1-6 shows life expectancy in water from hypothermia as functions of water chill and wind chill.

[38] The PSDA is described in *U.S. Coast Guard Addendum to the United States National Search and Rescue Supplement (NSS) to the International Aeronautical and Maritime Search and Rescue Manual (IAMSAR)*, section 3.7, "Aspects of Survival," COMDTINST M16130.2F, January 2013, downloaded December 27, 2016, at https://www.uscg.mil/directives/listing_cim.asp?files=20&id=16000-16999.

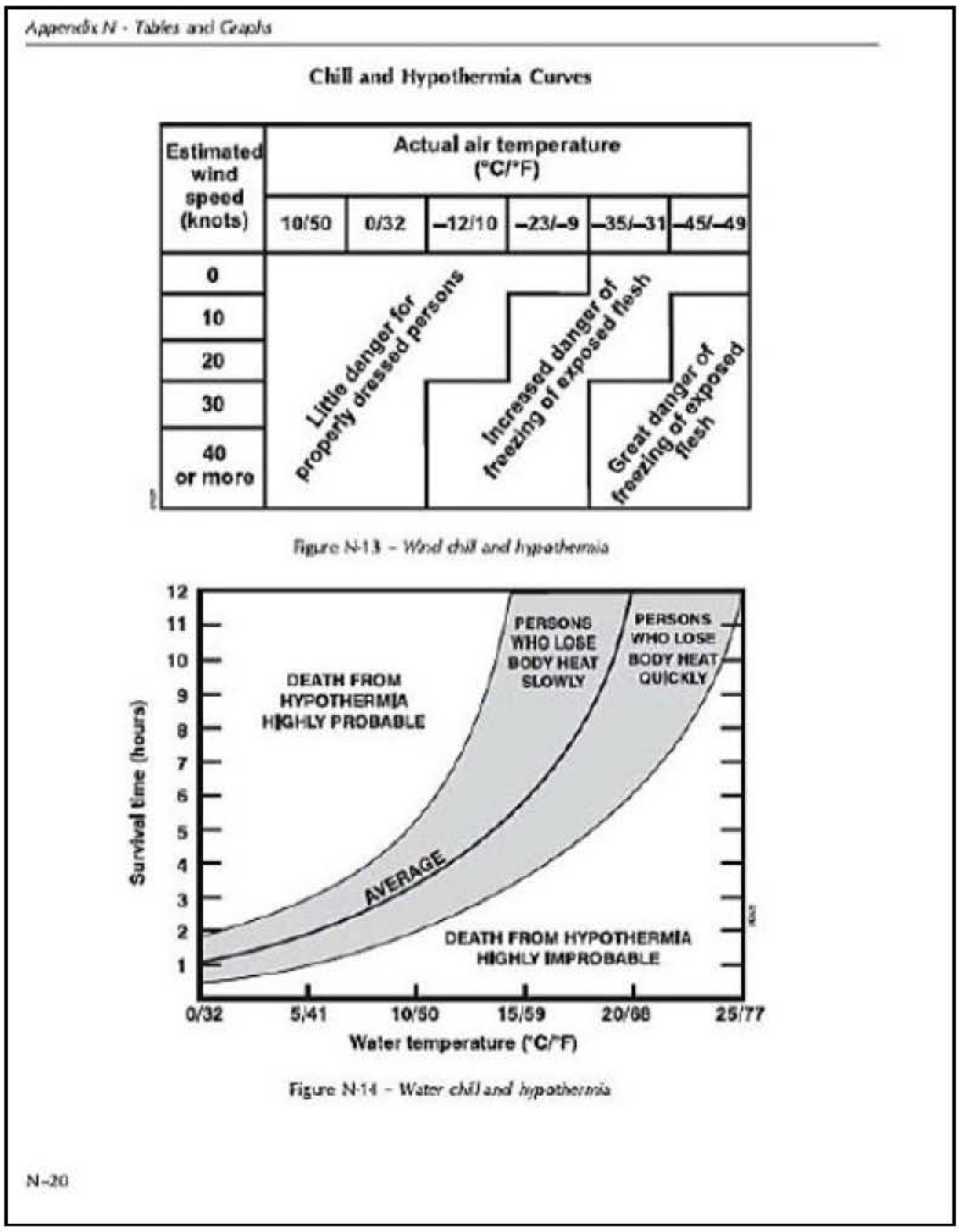

Figure A1-8. Chill and hypothermia curves. Top figure shows danger of hypothermia as a function of air temperature and wind speed. Bottom figure shows death from hypothermia as a function of water temperature and time immersed in water. [39]

[39] IMO/ICAO, *IAMSAR Manual* (*International Aeronautical and Maritime Search and Rescue Manual*), vol. II, "Mission Co-Ordination" (London/Montreal, 2007), figure N-14.

The PSDA predicts functional time and survival time based on cooling of the body's core and water lost by sweating, respiration, and urine production. The times are based on an individual's physical characteristics, clothing, weather, and sea conditions. The functional time predicted by the PSDA is the time elapsed after initial exposure when a person's body core temperature decreases to the end of mild hypothermia at 93.2° F, when the person is assumed to have lost the cognitive capacity to prolong life. Survival time is the time after immersion when the person's core body temperature falls to the end of moderate hypothermia at 82.4° F, the point at which a person is expected to lose consciousness. An immersed unconscious person is unable to maintain an airway, which quickly results in drowning. The factors affecting the onset of exhaustion are poorly understood by the physiological community, so the hypothermic survival time was limited to 120 hours or less, based on the maximum observed immersed survival time (90 hours) from existing Coast Guard records, with a 33 percent added margin of safety.[40]

In warm air conditions (land or sea), a second physiological model in the PSDA predicts total dehydration (water loss) through the skin (sweat loss), lungs (respiratory loss), and metabolic waste (urine) production. The accepted minimum daily requirement for additional fresh water at sea is about 1 quart. When water loss exceeds about 5 percent of body weight, a person may experience headaches, irritability, and lightheadedness. With about 8 to 10 percent body loss of water, performance deteriorates significantly, with dizziness, faintness, rapid pulse, and shallow breathing. Beyond 10 percent of body loss of water, deterioration increases and hallucination and delirium become common. Dehydration survival time is reached when a person has lost 15 to 20

[40] Section 3.7.1.3, "Limitations of the PSDA," COMDTINST M16130.2F, p. 3-88.

percent of his or her body weight. The PSDA developer set a maximum expectation of survival at 10 days (240 hours), based on recommendations of earlier researchers.

PSDA version 1.0 for *El Faro* used the following inputs: air temperature 81° F; water temperature 84° F; relative humidity 76 percent; wind speed 13.6 knots; gender female; height 5′ 4″; weight 154.8 pounds; fat 34 percent; immersed in water to the neck; turbulent heat loss; wearing survival suit. The calculated survival time was 120 hours.

Personal Locator Beacon

A personal locator beacon (PLB) is a portable unit that operates like an EPIRB. It was originally developed for land use in Alaska but was authorized for nationwide use on July 1, 2003. The PLB is designed to be carried by a person. PLBs are registered through the FCC to a person, not a vessel or aircraft. The PLB is activated manually and operates on 406 MHz to get an accuracy of within 3 miles using the 406 MHz satellite system. The PLB has a low-power homing beacon that transmits on 121.5 MHz frequency. Newer PLB models allow GPS input to the distress signal to achieve an accuracy of about 100 meters.[41] PLBs are not required at sea, but several manufacturers offer marine PLBs costing between $300 and $400.[42]

[41] "Emergency Beacons, Search and Rescue Satellite Aided Tracking (SARSAT)," National Oceanic and Atmospheric Administration (NOAA) downloaded May 17, 2017 at http://www.sarsat.noaa.gov/emerbcns.html.

[42] "Personal Locator Beacons (PLBs)," West Marine downloaded June 25, 2017 at https://www.westmarine.com/personal-locator-beacons-plbs.

Figure A1-9. Marine 406 MHz personal locator beacon (Ocean Signal).[43]

Immersion Suit Standards

Immersion suits are insulated, buoyant suits designed to prevent shock on entering cold water and lessen the effects of hypothermia.[44] The adult-size suit must fit males and females ranging in weight from 50 kilograms (110 pounds) to 150 kilograms (330 pounds) and in height from 1.5 meters (59 inches) to 1.9 meters (75 inches). The small-adult or child-size suit must fit males and females ranging in weight from 20 kilograms (44 pounds) to 50 kilograms (110 pounds)

[43] Photo of Ocean Signal personal locator beacon downloaded May 18, 2017, at http://oceansignal.com/products/plb1/.

[44] Regulations for immersion suits are found at 46 CFR 160.171.

and in height from 1.0 meter (39 inches) to 1.5 meters (59 inches). An oversize adult suit is intended for a person too large for the standard adult suit.[45]

Immersion suits must meet performance requirements. Each suit must be designed so that a person can don the suit correctly within 2 minutes. The suit's righting requirement is to turn the body of an unconscious person in the water from any position/face-down position to one where the mouth is clear of the water/face-up in not more than 5 seconds without assistance. The suit must prevent undue water penetration into the suit for 1 hour when floating in calm water. The suit must have a means of splash protection to prevent water spray from directly entering the wearer's mouth. The suit must not burn or melt continuously when enveloped in fire for 2 seconds. The suit must be oil-resistant and be usable after a 24-hour exposure to diesel oil. The suit must provide thermal protection. The wearer's body core temperature cannot fall more than 2° C (3.6° F) after jumping into water from a height of 4.5 meters and 6 hours' immersion in calm, circulating cold water with a temperature of between 0° and 2° C (32° to 35.6° F).[46]

[45] Size requirements for immersion suits are found at 46 CFR 160.171-9(m).

[46] Performance requirements for immersion suits are found at 46 CFR 160.171-11(a) buoyancy, (b) righting, (c) thermal protection, (d) donning time, (e) vision, (f) water penetration, (g) splash protection, (h) storage temperature, (i) flame exposure, and (j) oil resistance.

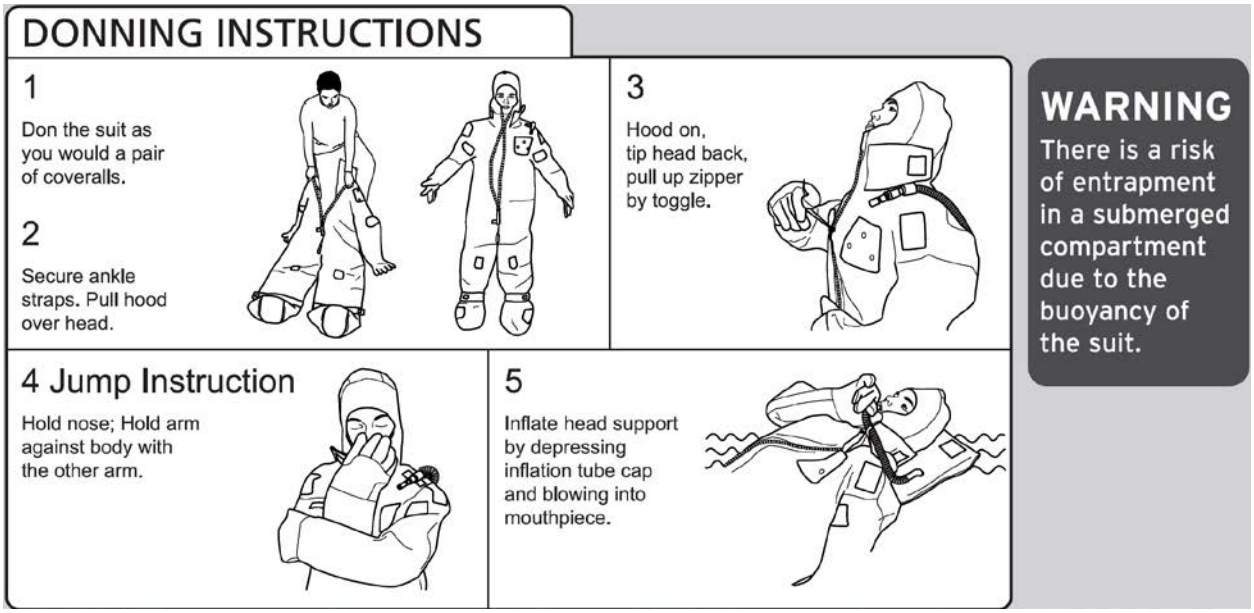

Figure A1-10. Donning instructions for immersion suit (Mustang Survival).[47]

Immersion Suit Test

The Marine Board of Investigation asked that an experiment be conducted to see if immersion suits, such as those carried on *El Faro*, retained flotation capacity after an extended period in the water. In June 2016, the Coast Guard Research and Development Center tested two weighted mannequins dressed in Coleman-Stearns I590 immersion suits.[48] The mannequins floated in benign water conditions of the Mobile River, Alabama, for 2 weeks. On recovery, researchers concluded that the immersion suits retained flotation. They observed that little water intruded (less than a liter) into each immersion suit, but that a significant amount of added weight (about 10 pounds) of seaweed had accumulated at the waterline of each suit.

[47] Also see video "Survival Suit Demonstration at US Coast Guard Station Gloucester," goodmorninggloucester.org downloaded May 22, 2017, at https://www.youtube.com/watch?v=SQxyr2fIu0c.

[48] *Immersion Suit Flotation Testing REACT (Rapid Evaluation and Analysis of Critical Technologies) Report*; M. J. Lewandowski and C. J. Clark, US Coast Guard Research and Development Center, New London, Connecticut, 2016, downloaded December 23, 2016, at https://www.uscg.mil/acquisition/rdc/Reports/2016/CG-D-08-16.pdf

Liferaft Standards

As adopted by the SOLAS 1983 amendments and applied retroactively, liferafts are required to accommodate the total number of persons on board a vessel. An extra liferaft (holding 6 persons) is required for vessels over 100 meters.

3. In addition to their lifeboats, cargo ships constructed before 1 July 1986 shall carry not later than 1 July 1991[49]

.1 One or more liferafts of such aggregate capacity as will accommodate the total number of persons on board. The liferaft or liferafts shall be equipped with lashing or an equivalent means of securing the liferaft which will automatically release it from a sinking ship;

.2 Where the survival craft are stowed in a position which is more than 100 m from the stem or stern, in addition to the liferafts required by paragraph 3.1, a liferaft stowed as far forward or aft, or one as far forward and another as far aft, as is reasonable and practicable. Notwithstanding the requirements of paragraph 3.1, such liferaft or liferafts may be securely fastened so as to permit manually release.

Liferafts are launched either (1) manually by removing their lashings and throwing/dropping overboard, (2) hydrostatically, or (3) by davit. [50]

[49] SOLAS 1983 Amendment, Section III, "Cargo Ships (Additional Requirements," regulation 26, "Survival Craft and Rescue Boats, "p. 317.

[50] There is no SOLAS/LSA code requirement for liferafts to be launched with a lever. Viking Life-Saving Equipment A/S states that at the customer's request, Viking will install the HAMMAR Manual Remote Release System (MRRS) that allows one person activating a remote lever to launch liferafts. Viking Life-Saving Equipment A/S email re: HAMMAR MRRS Sep.2014.pdf from Viking Director of Rules & Regulations to NTSB, December 22, 2016.

The inflatable liferafts on *El Faro* were manufactured by Viking Life-Saving Equipment and by Elliot (Survitec Group). According to Viking, the liferafts were type-approved, manufactured, examined, and serviced in conformity with 46 CFR 160.151, which incorporates by reference the following standards of the International Maritime Organization (IMO), as amended:[51]

- IMO International Convention on Safety of Lives at Sea (SOLAS) 1974.
- IMO International Life-Saving Appliances (LSA) code (MSC.48(66)).
- IMO revised recommendation on testing of life-saving appliances (MSC.81(70)).
- IMO recommendation on conditions for the approval of service stations for inflatable liferafts (A.761(18)).

According to Viking, none of the above instruments provides any details about operational conditions or limitations, but the company uses as guidance 46 CFR 160.151-15, -17, and -27, which largely set the performance and test requirements for SOLAS inflatable liferafts by incorporated references to the LSA code and the revised recommendation on testing of life-saving appliances:

- LSA code paragraph 1.2.2.8, on general requirements for all LSA requires that if they are to be used in a seaway that they be capable of satisfactory operation in that environment.
- LSA code paragraph 4.2.5.1, on the stability of inflatable liferafts in a seaway.

[51] Viking Life-Saving Equipment Ltd letter, re: "VIKING inflatable liferafts on board *El Faro* sinking October 1, 2015," from Viking Director of Rules & Regulations to NTSB, August 19, 2016

Viking notes for both paragraphs 1.2.2.8 and 4.2.5.1 that a definition or specifications of "a seaway" is absent in all referenced instruments.

- LSA code paragraph 4.1.1.1, requiring that "every liferaft shall be so constructed as to be capable of withstanding exposure for 30 days afloat in all sea conditions."

According to Viking, the following test requirements could apply:

- MSC.81(70) paragraph 5.5, on a 30 days' mooring-out test where an inflated and fully laden liferaft is left afloat for 30 days at sea or in a harbor.
- MSC.81(70) paragraph 5.12, on canopy closure test in which the canopy is subject to a hose test exerting a considerable force on the canopy.
- MSC.81(70) paragraph 5.20, on various tests to be performed in wind conditions of 30 m/s (58.3 knots).
- MSC.81(70) paragraph 5.17.13.2.3, on test requirements for outer canopy fabrics.
- MSC.81(70) paragraph 5.19, on submergence test for automatically self-righting and canopied reversible liferafts to be performed in a sea state of at least 2 m significant wave height in association with a wind force of Beaufort force 6. [52], [53]

[52] As described in Nathaniel Bowditch, *American Practical Navigato*r, chapter 36, "Weather Observations," force 6 entails wind speeds of 22-27 knots and wave heights of 3-4 meters (9.5-13 feet). "Larger waves forming, whitecaps everywhere, more spray" (p. 540).

[53] Note that the liferafts on *El Faro* were not of the automatically self-righting or canopied reversible type and as such not subject to this test.

- MSC.81(70) paragraph 12.6.2, on a performance test for marine evacuation systems including associated liferafts in a sea state associated with a wind of force 6 on the Beaufort scale, and in association with a significant wave height of at least 3 meters.[54]

For tests to be performed during various years of servicing such as the necessary additional pressure (NAP) test, frequency is per 46 CFR 160.151-57, incorporating the IMO recommendation on conditions for the approval of service stations for inflatable liferafts.[55] The NAP test was not omitted at *El Faro*'s last annual service and was due at the next annual servicing.

SOLAS chapter III, regulation 20, part 8, states that inflatable liferafts shall be serviced at intervals not to exceed 12 months, but that the administration (flag state) may extend this period to 17 months. The servicing must be done at an approved servicing station, which maintains proper servicing facilities and uses only properly trained personnel.

Lifesaving Drill Standards

The Coast Guard's *Marine Safety Manual*, volume II, change 1, contained the guidance for materiel inspection of vessels at the time of *El Faro*'s sinking. Coast Guard inspectors conducting initial inspection of domestic vessels determine the time required for two crewmembers to prepare a lifeboat for launching. The time starts with the two-crewmembers at the boat launching station and the boat stowed, as it normally would be when the vessel is at sea. Preparation is complete

[54] Note that the liferafts on *El Faro* were not associated with a marine evacuation system and as such not subject to this test. According to Viking, "In terms of prescriptive sea conditions during testing of any life-saving appliances and arrangements, this is the most demanding of all above-referenced instruments."

[55] The NAP is required at yearly intervals for liferafts older than 10 years by SOLAS resolution A.761(18), "Recommendation on Conditions for the Approval of Servicing Stations for Inflatable Liferafts" (appendix 1, "Necessary additional pressure (NAP) test," and appendix 2, "Frequency of NAP tests"), November 1993.

once a launching crew (at least three persons) is on board and ready for launch. The time to prepare the boat for launching must be 5 minutes or less.[56]

Coast Guard inspectors conducting domestic vessel certification hold an abandon-ship simulation to determine the time for all persons on board to launch a survival craft into the water. For cargo ships, the abandon-ship time must be 10 minutes or less. [57]

Survival Gear Discovered—Life Preserver (Lifejacket)

None of the *El Faro* crew's life preservers (PFD) were recovered after the sinking. However, while naval architects viewed video from the VDR search mission in January 2017, a life preserver with reflective material was spotted on the ship's deck house aft starboard boat deck. It was beneath debris leaning against the house and appeared to be attached to the walkway safety rail near the top of the ladder that led down to the cabin deck.

[56] *United States Coast Guard Marine Safety Manual, Volume II: Materiel Inspection*, section B, "Domestic Inspection Programs," chapter 1, "Inspection of Vessels for Certification," part 2, "Initial inspections," p. B1-83 (COMDTINST 16000.7B change 1, June 25, 2014).

[57] *Marine Safety Manual, Volume II*, "Abandon-Ship Simulation," pp. B1-108 to B1-109.

Figure A1-11. Life preserver, or personal flotation device (PFD), with reflective material discovered on *El Faro*'s aft boat deck walkway rail, starboard of centerline. Still photo taken on third VDR search mission by remotely operated vehicle CURV-21 and time-stamped 8/9/2016 09:10:06.